Current Trends in Technology and Sciences
Volume : 1, Issue : 1 (May-June-2012)

Impact of Storage Structures and Soil Sodicity on Vitamin C Contents of Stored Oranges

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Abstract - A study was carried out on the impact of storage structures and soil sodicity on vitamin C contents of stored oranges. Three sets of four different types of passive evaporative cooling structures made of two different materials, clay and aluminium were constructed. One set consists of four separate cooling chambers. Two cooling chambers were made with aluminium container (round and rectangular shapes) and the other two were made of clay container (round and rectangular). These four containers were separately inserted inside a bigger clay pot inter-spaced with clay soil of 5 cm (to form tin-in-pot, pot-in-pot, tin-in-wall and wall-in wall) with the outside structure wrapped with jute sack. The other two sets followed the same pattern with interspacing of 7 cm and 10 cm respectively. The set with 7 cm interspace served as the control in which the interspace soil and the jute sack were constantly wetted at intervals of between 2 to 4 hours depending on the rate of evaporation with water at room temperature. The other two sets (5 cm and 10 cm interspaced soil) were constantly wetted with salt solution (sodium chloride, NaCl) at the same interval to keep the soil in moist condition. In addition, the control has no fans and the inner cooling chambers were not lined with polyethylene nylon while the other two sets have fans and their inner cooling chambers lined with polyethylene nylon. Freshly harvested oranges were used for the experiment and the temperature and relative humidity of the storage chambers and the ambient were monitored on daily basis at 8.00am, 12 noon and 6.00pm while the vitamin C contents were determined at interval of three days for a period of three weeks. The oranges kept inside the tin-in-wall and wall-in-wall structures in all the three interspaces retained the highest amount of vitamin C at the end of the storage period. The vitamin C values of 32.42 mg/100ml, 30.68 mg/100ml, 33.98 mg/100ml and 34.94 mg/100ml were recorded for the tin-in-pot, pot-in-pot, tin-in-wall and wall-in-wall respectively for the 5 cm soil interspace. The vitamin C values of 31.78 mg/100ml, 30.80 mg/100ml, 32.94 mg/100ml and 33.32 mg/100ml were recorded for the tin-in-pot, pot-in-pot, tin-in-wall and wall-in-wall respectively for the 7 cm soil interspace while the vitamin C values of 31.54 mg/100ml, 31.16 mg/100ml, 33.42 mg/100ml and 33.54 mg/100ml were recorded for the tin-in-pot, pot-in-pot, tin-in-wall and wall-in-wall respectively for the 7 cm soil interspace. Overall, the 7 cm soil interspace structures recorded the least amount of vitamin C of 128.84 mg/100ml while the 5 cm and 10 cm soil interspace structures recorded higher values of vitamin C contents of 132.02 mg/100ml and 129.66 mg/100ml respectively.

Keywords - Vitamin C, sodicity, storage, oranges, soil.

1. INTRODUCTION

Oranges come in many varieties, and are grown in several regions of the world. Oranges originated thousands of years ago in Asia, in the region from Southern China to Indonesia from where they spread to India, Caribbean and then to the rest of the world (Rainer, 1975). There are many varieties of oranges of which the most popular include the Clementine, kumquat, mandarin, Minneola, navel, tangerine, tangelo, Valencia, hamlin and ugly (Nicolosi *et al*., 2000; Reuther *et al*., 1967). They all belong to the family of *Rutaceae* and are good sources of antioxidants.

Antioxidants are very important in maintaining good health and it is the general name for the vitamins, minerals, carotenoids and others that protect the body from harmful free radicals (Harman, 1992). A large number of antioxidants in food contribute to disease prevention and these include vitamin A, vitamin C, Vitamin E and the carotenoids as the major nutrient (Padayatty *et al*., 2003; Brigelius *et al*., 1999). Recent researches conducted at the University of Innsbruck, Austria suggests that as fruits fully ripen, almost to the

point of spoilage, their antioxidants level actually increases.

Oranges are important sources of vitamin C and can be useful when consumed to fight off ailments such as? (Van't *et al*., 2000). The body requires Vitamin C to form and maintain bones, blood vessels and skin. It also helps build and maintain tissues and strengthens immune system. Vitamin C activity may be helpful in the prevention of some cancers and cardiovascular diseases (Barber and Barber, 2002). Deficiency symptoms of vitamin C include general weakness of the body, depression, anaemia, increased susceptibility to infection, male infertility, scurvy, bleeding gums, rashes on the legs, joint and muscle ache (Steimetz *et al*., 1996).

The high dose of vitamin C (more than 2,000 mg daily) can cause diarrhoea, stomach upset, nausea among others (Khachik *et al*., 2002). The balance between the production of free radicals and the antioxidant defences in the body has important health implications. Free radicals have been implicated in several health problems. Some free radicals arise normally during metabolism but some environmental factors such as pollution, radiation, smoke from cigarette and herbicides can also spawn free radicals (Knight, 1998). Normally, the body can handle free radicals, but if antioxidants are unavailable, or if the production of free radicals becomes excessive, damage can occur (Valko *et al*., 2007).

The best approach to the problems of free radical and ageing is to identify and avoid the major causes of free radical production, and ensure that one gets enough antioxidants through diet and anti-ageing supplements to prevent damage (Cho *et al*., 2004; Knight, 1998).

The important features of the environment which influence the longevity of fresh produce and which are amenable to control are temperature, relative humidity and composition of the atmosphere surrounding the produce. According to Richard and Priester (1986), too low humidity in storage causes shrinking or water loss and too high humidity promotes the growth of mould with possible spoilage of the product. However, the conservation of most fresh produce is enhanced solely by cooling to the most suitable temperature immediately after harvest. This is because low temperature depresses both the physiological activity of vegetable tissues themselves and any microorganism capable of causing spoilage; hence the storage life is extended. Proper temperature management can be a very effective tool in ensuring that produce remains in good condition throughout the storage period (Mitra, 1997). Oranges are stored at 12^{o}C and their trees are evergreen.

Oranges can either be stored at room temperature or in the refrigerator. They will generally last the same amount of time, two-weeks with either methods and will retain nearly the same level of their vitamin content. After harvesting, oranges have a shelf life of about one week at room temperature and one month if refrigerated. In either case, they are optimally stored loosely in an open or perforated plastic bag. The best way to store oranges is loose rather than wrapped in plastic bag, since if exposed to moisture, they can easily develop moulds (Spiegel-Roy *et al*., 1996).

Many researchers have worked on the physical and chemical properties of saline and sodic soils and how they affect soil structure (Gallali, 1980; Bramely *et al*., 2003; Gardner, 2004; Valzano *et al*., 2001). Sodicity is caused by the specific effect of sodium ions adsorbed in the soil (Gallali, 1980). This study focuses on the impact of storage structures and soil sodicity on the vitamin C contents of stored oranges.

2. Materials and Method

Mature green oranges were obtained from Minna Central Market in Niger State and transported in wooden crates to the laboratory. In the laboratory, mechanically damaged samples were removed and the undamaged samples were washed in running tap water. One hundred and twenty (120) fresh orange fruits were divided into four (4) lots of thirty (30) and put in the designed and constructed passive evaporative coolers. The fresh oranges were stored for a period of three-weeks.

3. Determination of Temperature and Relative Humidity

The temperature and relative humidity of the fresh oranges stored in the different passive evaporative coolers were measured daily and compared with the ambient using a digital thermometer and a relative humidity measuring instrument (Testo 625 Compact Instrument). The temperatures and the relative humidities of the storage environment were taken three times daily at 8.00am, 12.00 noon and 6.00 pm and their averages were determined.

4. Nutritional Analysis

Nutritional Analysis of orange samples was carried out in the Central Laboratory of National Cereals Research Institute, Badeggi, Niger State. The nutritional parameters evaluated were vitamin C contents using AOAC (1996) methods of analysis. All measurements were performed in triplicates and results were given as mean ± standard error (SE).

5. Preparation of Salt Solution

About 15000 parts/millions (ppm) solution of sodium chloride (NaCl) was prepared by dissolving 225g of NaCl in 15 litres of water at room temperature and 450g of NaCl in 30 litres of water at room temperature for keeping the four structures in moist condition in the 5 cm and 10 cm soil inter-spaces respectively. The four structures in the 7 cm soil inter-space were kept in moist condition using 20 litres of water.

6. RESULTS AND DISCUSSION

Temperature of Stored Oranges inside the Evaporative Cooling Structures

The effect of temperature on various storage conditions in the storage structures is presented in Figures 1- 3. Generally, temperatures in the evaporative cooling structures are lower than that obtained for the ambient. This is an indication of the effectiveness of the evaporative cooling structures. This may be attributed to the cooling effect of the evaporative cooler. Wetting of the jute sacks and the evaporation of water in the soil also helped in reducing the temperatures ((Thompson, 1998). The shade provided for the evaporative cooling structures as well as the wooden covers also helped in reducing the temperatures (Roy and Khudiya, 1984).

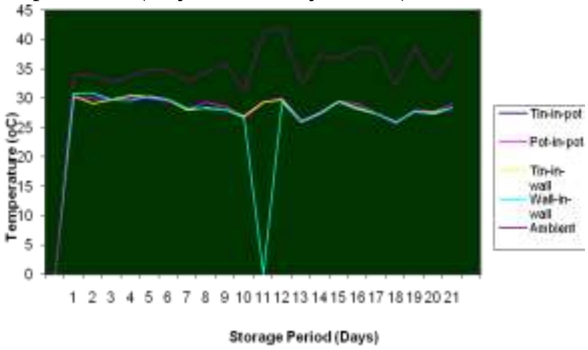

Figure 1: Variations in Temperature in Different Passive Evaporative Coolers (5CM Interspace) and the Ambient

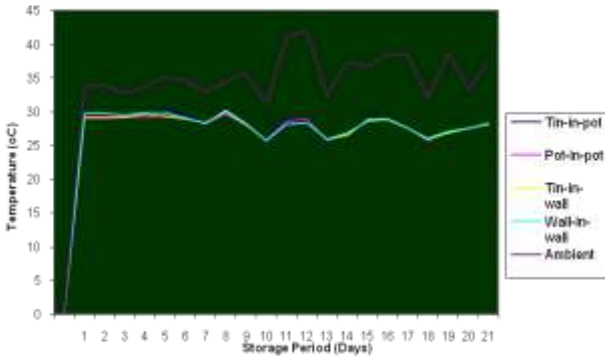

Figure 2: Variation in Temperature in Different Cooling Systems (7 cm Interspace) and the Ambient

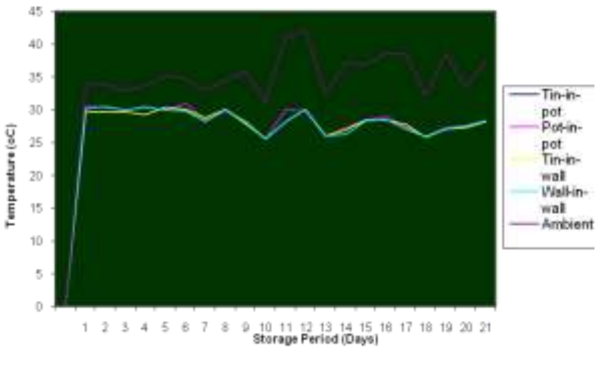

Figure 3: Variation in Temperature in Different Cooling Systms (10cm Interspace) and the Ambient

7. VITAMIN C CONTENT OF STORED ORANGES

The summary of the results of the vitamin C content determined is presented in Table 1. The higher percentage of vitamin C content of stored oranges in Tin-in-wall and Wall-in-wall was as a result of lower temperatures which tend to slow down the metabolism (including respiration) which eventually reduced the extent of activities of microorganisms and chemical reactions taking place inside the structures. Also the higher percentage of vitamin C content of stored oranges in Tin-in-wall and Wall-in-wall may be as a result of higher rate of ripening taking place as reported by Abushifa *et al*. (1997) and Giovanelli *et al*. (1999). Also methods of regulating ripening and deterioration are only supplemental to low temperature storage (Pantastico, 1975). Low temperature prolongs storage life by reducing respiration rate as well as reducing growth of spoilage microorganisms (Rouraa *et al.*, 2000; Watada *et al*., 1996). Respiration is one of the basic physiological factors, which speeds up ripening of fresh commodities and is directly related to maturation, handling, and ultimately to the shelf life (Ryall and Lipton, 1979; Ryall and Pentzer, 1982). Generally, the loss of freshness of perishable commodities depends on the rate of respiration. An increase in respiration rate hastens senescence, reduces food value (including nutritional compositions) for consumers and increases the loss of flavour. Higher storage temperatures are known to have an increasing effect on the rate of decrease in ascorbic acid content in tomatoes during storage (Salunkhe *et al*., 1991).

Also the absence of salt solution on the 7 cm soil interspaced structures must have caused the reduced value of ascorbic acid contents by the action of microorganisms. The toxic nature of salt solution can reduce the action and growth of microorganisms (Alexopoulos *et al*., 1996).

Also control of postharvest decay of fruits and vegetables are based upon the prevention of infection before as well as after harvest, eradication of incipient infections and retarding the progress of the pathogen in the host by postharvest treatments such as disinfection (Eckert *et al*., 1975).

8. CONCLUSIONS

This study focuses on the impact of storage structures and soil sodicity on the vitamin C contents of stored oranges. From the results, the use of tin-in-wall and wall-in-wall structures is recommended which tends to slow down the microrganisms activities due to the lower temperatures recorded in those structures. Also it is recommended that wetting of the jute sacks and soil interspace should be done with salt solution in order to control the growth of microrganisms. With these, higher quality and better safety of stored produce would be achieved.

9. REFERENCES

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Table 1: Changes in Vitamin C Contents (mg/100ml) of Stored Oranges in Different Evaporative Coolers at Different Interspace

Storage Type	Interspace	Changes in Vitamin C Contents in Storage						
		day 1	day 5	day 8	day 11	day 15	day 18	day 21
Tin-in-pot	5 cm	34.51	41.44	39.70	38.74	38.86	31.64	32.42
Pot-in-pot		36.72	42.33	39.42	39.04	45.98	34.54	30.68
Tin-in-wall		34.32	39.56	40.04	34.32	36.54	32.78	33.98
Wall-in-wall		46.31	39.50	43.32	36.66	49.47	32.98	34.94
Tin-in-pot	7 cm	35.98	41.53	39.68	38.12	38.76	34.84	31.78
Pot-in-pot		34.33	41.76	39.61	39.62	44.72	38.61	30.80
Tin-in-wall		32.62	40.72	41.62	35.54	35.76	33.34	32.94
Wall-in-wall		45.14	39.32	44.16	37.78	42.06	32.78	33.32
Tin-in-pot	10 cm	36.62	41.21	39.66	39.12	39.04	33.78	31.54
Pot-in-pot		36.34	42.08	39.48	39.10	44.02	34.12	31.16
Tin-in-wall		34.59	40.82	42.94	36.32	36.44	33.84	33.42
Wall-in-wall		43.16	39.60	45.32	37.90	44.12	33.12	33.54